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# PORTRAIT OF THE PLANET MARS

Professor V. Moroz



Translation of "Portret Planet' Mars,"
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16. Abstract

The properties of Mars as determined by the Soviet and American space probes are reviewed. General information is presented on the surface characteristics, the composition of the atmosphere, the nature of the surface, and the question of the magnetic field in the vicinity of Mars. Brief mention is made of the instruments employed by the probes in study of the planet.

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# PORTRAIT OF THE PLANET MARS

Professor V. Moroz[1]

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The World in which man lives possesses a marvelous property. It is constantly expanding. Five thousand years ago the World of mankind was essentially a small space inhabited by half-savage tribes; beyond it lay the unknown. Five hundred years ago the inhabited space had expanded to embrace entire continents, and then came to cover the whole planet. The most daring people of the time plowed through the oceans and cut across the continents. This was the era of the major geographic discoveries.

We are living in a new era of great discoveries, but there is a different setting; it is now outer space. In place of the sailing ships, automated spacecraft are now traveling out into unexplored expanses, and the scale of measurement is all so different; now distances are not measured in thousands but in millions and hundreds of millions of kilometers.

Ten years ago we were studying the planets of the Solar System by the same methods used for the stars, heavenly bodies at immensely greater distances. And it may be said that we have been successful in our studies. Spectroscopic, photometric, and radio astronomy measurements of planets conducted with the aid of telescopes on Earth have revealed many interesting things about them. What we have learned about the neighboring planets of Venus and Mars as a result of the first flights of automated spacecraft toward them nevertheless have made no smaller a contribution to the science of planets than all the preceding history of study of them.

The hero of the day is now Mars, and it is about Mars that we will talk. Mars is not a very large planet — its radius is around 3,400 kilometers, this being approximately one-half the radius of the Earth. But at the same time Mars is approximately twice as large as the Moon. And this is what determines many of the characteristics of Mars. In certain respects Mars resembles the

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Moon: a large part of its surface is covered with craters formed as the result of bombardment by meteorite bodies, and its soil is broken up. But in many respects Mars also resembles the Earth. Mars has an atmosphere, although a rarified one (it is approximately 100 times less dense than that of the Earth), but it is quite enough, for example, to slow down a spacecraft which is to land on this planet. It has mountains of volcanic origin. The gigantic volcanic cone Nix Olympica has a diameter of around 500 kilometers and exceeds the volcanoes of Earth in size. The continental masses tower several kilometers above the oceanic depressions, just as on Earth, although it is true that these depressions are not filled with water.

The atmosphere of Mars differs from that of Earth in composition as well as in density. Carbon dioxide is one of its chief components. This gas represents no less than 50% of the atmosphere. There is little oxygen, about 0.1%, and approximately the same amount of carbon monoxide and water vapor. The water content of the atmosphere is customarily measured by using a highly graphic concept, the thickness of the layer of liquid water obtained if the water vapor in the atmosphere were to be condensed. On Earth the average thickness of this layer is around one centimeter, and on Mars a few thousandths of a centimeter. On Mars as on Earth the amount of vapor in the atmosphere varies from place to place on the planet, with the seasons, and even with the time of day. We must note that liquid water cannot exist on Mars; it must boil and evaporate because there is too little pressure.

Are there any other gases in the atmosphere of Mars, aside from carbon dioxide, in amounts comparable to the latter, not tenths of a percent but percent figures in multiples of ten? For example, there is more nitrogen than anything else in the Earth's atmosphere; is nitrogen present on Mars? The emission spectrum of the upper atmospheres of the Martian atmosphere contain no nitrogen radiation lines. Hence the conclusion has been drawn that it cannot be present in the atmosphere of Mars in amounts exceeding a few percent relative to carbon dioxide. The next important gas to be considered is argon. While the rate of escape of argon from the crust of Mars is the same as on Earth, the content of gas in the atmosphere may be several dozen percent on Mars.

The question of the argon content of the Martian atmosphere is directly related to the problem of evolution of the planet. Several possibilities are now being considered. The first is that Mars never had a dense atmosphere. Throughout its geological history it has been approximately the same as it is now. Another possibility is that Mars had a dense atmosphere and large amounts of liquid water on its surface hundreds of millions or billions of years ago, and then the atmosphere became thinner. A third version is that "only" a few million or even a few hundred thousand years ago Mars had an atmosphere of a density close to that of the Earth, as well as water on its surface, and in just as short a time may acquire one again, this change taking place repeatedly in the course of the geological history of the planet with a definite periodicity.

The third possibility, which at first appears to be extremely improbable, has in recent years won serious supporters. Why? Firstly, traces of water erosion, dry river beds the age of which does not exceed millions of years have been discovered on Mars. They are to be seen in the photographs taken by the "Mariner-9" two years ago and quite recently by the "Mars-5". There is a suspicion that 99% of the Martian atmosphere is frozen in the polar caps, which consist of condensed carbon dioxide ("dry ice") and water (ordinary ice). In order to confirm this suspicion it is important to prove that the escape of gas from the crust of Mars proceeds at the same rate as on Earth. If the proportion of argon in the Martian atmosphere reaches several dozen percent, this would be significant evidence in favor of such an assumption.

Among other things an instrument for measurement of the chemical composition of the atmosphere was installed on the "Mars-6" space probe. This instrument was developed at the Space Research Institute of the Academy of Sciences of the USSR (IKI AN SSSR) under the direction of Doctor of Physical and Mathematical Sciences V. Istomin. Analysis of the telemetric information obtained in the measurements in the atmosphere of Mars has revealed that the atmosphere contains several dozen percent of some sort of inert gas. This gas is most probably argon. Thus the first direct measurements ever made of the composition of the Martian atmosphere have yielded an answer to this highly important question concerning the entire history of the planet.

This experiment involving direct analysis of the chemical composition was only one of the elements of the large array of studies of Mars and interplanetary space conducted on the "Mars-4", "Mars-5", "Mars-6", and "Mars-7" space probes.

This array included studies both with the launched probe and with the orbital craft. The "Mars-6" probe investigated the matter of argon in the atmosphere of Mars, while two other similar problems, the content of water vapor and that of ozone, were examined by the "Mars-5" orbital craft by means of sensitive optical instruments recording the presence of these gases on the basis of absorption caused by them on specific wavelengths.

The methods of determining the water vapor content of the Martian atmosphere were developed by the author of this article and his coworkers at IKI AN SSSR and the P. K. Shternberg Space Astronomy Institute over a period of many years. The first measurements were made with the "Mars-3". They revealed amounts of water in the atmosphere of the planet which are relatively small even by Martian standards. This amount has now increased to reach 50-70 microns of precipitated water in the moister sections of the planet. It has additionally been discovered that the moisture content varies widely from place to place.

Ozone is a gas of which there is very little in the atmosphere of Earth, but which plays a highly important role in protecting the Earth's surface, and above all its biosphere, from the action of solar ultraviolet radiation. Is ozone present in the atmosphere of Mars? The American "Mariner" probe detected ozone bound in the solid substance of the polar caps, but the question of its presence in the atmosphere remains unanswered. A special photometer developed at our Institute under the direction of V. Krasnopol'skiy and installed on the "Mars-5" has demonstrated the presence of traces of ozone in the atmosphere as well.

Several experiments with the "Mars-5" were aimed at study of the physical characteristics of the surface of the planet. Television photography provided high-quality pictures of the surface, and various optical instruments simultaneously determined the brightness, spectral properties, and polarization, on

the basis of which one can indirectly assess the structure and composition of the surface, its altitude, and its temperature. Several of the instruments designed for measurements of this kind were developed at our Institute, in the laboratory of L. Ksanfomaliti. One of them measures the thickness of the atmosphere along the flight path and makes it possible to ascertain how it varies and thus to estimate topographic heights. Another instrument determines the temperature of the upper soil layer itself, on the basis of the intensity of infrared radiation.

At the same time, measurement is made of the temperature at a depth of several dozen centimeters on the basis of radiation in the radio range, by means of a radiotelescope installed on the probe. The radio astronomy experiment is being conducted by the IKI AN SSSR in collaboration with a number of other institutes. Study of the thermal radiation of the surface of the planet in the infrared and radio ranges yields data on the density and the structure of the soil.

Study of the planet on the basis of its radiation characteristics is a highly important source of information.

The range of wavelengths covered is a very wide one: the radiotelescope operates on the longest wave, and the shortest one enters the region of gamma radiation. The studies of the gamma radiation of the planet by means of the "Mars-5" probe, which were conducted under the direction of Doctor of Physical and Mathematical Sciences Yu. Surkov of the Institute of Geochemistry and Analytical Chemistry of the Academy of Sciences of the USSR, will yield information on the composition of the Martian rocks. The shortwave ultraviolet radiation of the upper atmosphere of Mars provides information on its temperature, composition, and extent. This experiment is being conducted at IKI AN SSSR by the laboratory of Doctor of Physical and Mathematical Sciences V. Kurt.

The problem of the magnetic field of the planet is one of great interest. The measurements initiated with the "Mars-2 and 3" have been successfully continued with the "Mars-5", under the direction of Associate in Physical and Mathematical Sciences Sh. Dolginov of the Institute of Terrestrial Magnetism and Radio Wave Propagation of the Academy of Sciences of the USSR.

In 1971 the magnetometers of the "Mars-2" and "Mars-3" detected in the immediate vicinity of the planet a magnetic field of the order of 30 gamma, this exceeding by a factor of 7-10 the undisturbed interplanetary field transferred by the flux of charged particles escaping from the Sun. The field of interplanetary origin may be intensified on interaction with the planet, but certain features of the spatial characteristics of the magnetic field in the vicinity of Mars permit the assumption that it belongs to the planet itself. The measurements conducted with the "Mars-5" provided additional arguments in support of this hypothesis.

A separate set of instruments installed on the "Mars-4" and "Mars-5" probes recorded the particles of solar wind both in the vicinity of the planet itself and along the entire flight path from Earth to Mars. The neutral interplanetary gas was also studied along the flight path by means of an ultraviolet photometer. Preliminary data indicate that the solar system is filled with neutral hydrogen of a density of around one atom to every 10 cubic centimeters of space.

Processing of the results obtained with the Martian probe has only begun. But even the first data indicate that we are studying a living planet subjected to rapid changes. Will future expeditions to it find life in the proper sense of the word; does Mars have a biosphere at least of a very simple form?

The fresh data on the planet obtained over the last few years, and especially during the last month, more and more permit the hope that the answer will be an optimistic one. At any rate, in the recent geological past Mars apparently had a dense atmosphere and hydrosphere, that is, the conditions necessary for generation of life. It is not impossible that such periods will be repeated again in the future and Mars will become a second Earth to our remote descendants.

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